Nuclear Cooperation Meeting on Spent Fuel
and High-Level Waste Storage and Disposal
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I Introduction

In 1953, US President Dwight Eisenhower, in a speech at the United Nations, spoke about the dangers and the promises of what he called "atomic materials". He said:

"It is not enough to take this weapon out of the hands of the soldiers. It must be put into the hands of those who will know how to strip its military casing and adapt it to the arts of peace. The United States knows that if the fearful trend of atomic military build-up can be reversed, this greatest of destructive forces can be developed into a great boon for the benefit of all mankind. The United States knows that peaceful power from atomic energy is no dream of the future. That capability, already proved, is here now – today." [2]

In proposing what is now the IAEA, Eisenhower said

"Experts would be mobilized to apply atomic energy to the needs of agriculture, medicine and other peaceful purposes. A special purpose would be to provide abundant electrical energy in the power-starved areas of the world."[3]

With these goals, it was unfortunately easy to neglect any problems associated with the waste produced as nuclear power spread. We now are facing those problems, both those from the use of commercial nuclear power and, in a few countries, such as the United States, of the wastes produced as the reversal Eisenhower hoped for did not come to pass.

President Carter recognized the value and the challenges of nuclear power in 1977 when he said:

"There is no dilemma today more difficult to resolve than that connected with the use of nuclear power. Many countries see nuclear power as the only real opportunity, at least in this century, to reduce the dependence of their economic well being on foreign oil – an energy source of uncertain availability, growing price, and ultimate exhaustion. The U.S., by contrast, has a major domestic energy source – coal – but its use is not without penalties, and our plans also call for the use of nuclear power as a share in our energy production. The benefits of nuclear power are thus very real and practical. But a serious

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[2] "Atoms for Peace", United Nations General Assembly, 8 December 1953.
[3] *Ibid.*

risk accompanies worldwide use of nuclear power – the risk that components of the nuclear power process will be turned to providing nuclear weapons." [4]

The promise of nuclear as a benefit was tinged with the worry of proliferation. Waste also began to be noticed as a problem.

US Presidents have taken actions to move ahead with that problem:

In 1976, before the formation of the DOE, President Ford said:

"The area of our domestic nuclear program dealing with the long-term management of nuclear waste from our commercial nuclear power plants has not in the past received sufficient attention….I have been assured that the technology for long-term management or disposal of nuclear wastes is available but demonstrations are needed. I have directed the Administrator of ERDA [a predecessor of DOE and a successor of the AEC] to take the necessary action to speed up this program so as to demonstrate all components of waste management technology by 1978 and to demonstrate a complete repository for such wastes by 1985."[5]

This optimistic schedule, of course, was not met. Ford did acknowledge another facet of the difficulties when he said:

"I do not underestimate the challenge represented in… capturing the benefits of nuclear energy while maintaining needed protection against nuclear proliferation. The challenge is one that can be managed only partially and temporarily by technical measures."[6]

I will return to the non-technical challenges.

Ford's urging to move forward was echoed by President Carter in several early actions, such as establishing a senior-level inter-agency task group to recommend how to develop procedures to work with the states. Carter also directed that the government would take title to the commercial spent fuel. However, these were overshadowed by the Administration's push to halt worldwide reprocessing.

In 1981, President Reagan said:

"I am instructing the Secretary of Energy, working closely with industry and state governments, to proceed swiftly toward deployment of means of storing and disposing of commercial, high-level radioactive waste. We must take steps now to accomplish this

[4] "Nuclear Power Policy", Statement by the President on His Decisions Following a Review of U.S. Policy, 7 April 1977, Presidential Documents, Vol. 13, No. 15, p. 506.
[5] "Nuclear Policy", Statement by the President, 28 October 1976, Presidential Documents, Vol. 12, No. 44, p. 1624.
[6] *Ibid.*

objective and demonstrate to the public that problems associated with management of nuclear waste can be resolved."[7]

We are here today because those problems have not been resolved and we know that rapid movement has not occurred, although progress has been made. The problems in implementing these presidential directives turned out to be many more and much larger than those drafting these presidential statements realized. And many of these problems were not technical.

The letter of invitation stated this meeting would "…focus on the technical challenges presented by the long-term disposition of spent fuel in an enduring, environmentally sound, and proliferation sensitive manner."

While interesting and important, such a focus will not lead to success, at least in this country.

I told the organizers I would speak to the following topics:

- Intergenerational and environmental justice
- plutonium mines
- geologic uncertainties
- transportation hazards
- need for the material in spent fuel

II Intergenerational equity and environmental justice

(a) Intergenerational equity

Last November, the National Research Council Board on Radioactive Waste Management held a workshop on disposition of radioactive waste through geologic disposition. Some of you attended that meeting.

One handout prepared by DOE at that meeting stated:

"The principle of intergenerational equity requires that the generation deriving the benefit should pay its costs and that the current generation should not limit the options available to future generations."

[7] "Nuclear Energy Policy", Announcing a Series of Policy Initiatives: 8 October 1981, Administration of Ronal Reagan, 1981, p. 1101.

This is one view of what is meant by intergenerational equity, and is the view that can be found in many international documents, such as those from the OECD and the IAEA. In this view, the users of the technology should be sure any hazards resulting from that use are taken care of. This is a variation of the "Polluter Pays" principle embedded in many US regulatory approaches and enshrined in many Superfund law suits. Since the nuclear plants were used to generate electricity consumed by current society, then this intergenerational equity concept is that current society should be responsible for permanent disposal of the radioactive waste generated by the nuclear plants. Although I have not seen the argument made in the following way, I suppose one could similarly argue that the nuclear weapons produced during the cold war were the reason that neither opponent attacked the other. In that view, we benefited, so we should take care of the waste. (Probably many would not argue this way, but would say that we fouled the environment at the weapons production sites, so we should clean up those sites.) Those supporting this intergenerational equity concept argue that geologic disposal is the only reasonable approach to handling this responsibility.

But there is another perspective on intergenerational equity, one presented by Notre Dame philosophy professor Kristin Shrader-Frechette. She approaches the intergenerational equity issue using a concept from medical research and doctor-patient relationships. This concept is informed consent.

Two examples of when this was not followed:

A few years ago, the US government reported that decades ago patients were treated with radioactive materials to test the effects of those materials, to prepare, for example, for accidents or exposures to workers in facilities where radioactive materials are present or for exposures in nuclear war. The patients were not told of what was being done.

Similarly, many US military personnel were exposed to radiation during surface and above-surface nuclear tests. While knowing that they were involved in nuclear tests, they were not given explanations of the hazards.

A 1999 report by the US Institute of Medicine wrote that:

"There are standard, not mutually exclusive, ways of looking at how to ethically justify placing some at risk for the benefit of others: *consent* and *role-related responsibility*. In many circumstances it is considered ethically justified to place individuals at risk for the benefit of others if they consent to that imposition. To be ethically valid, the consent must be based on an adequate understanding of the nature and the implications of the risk, and the person must be free to refuse. Another way of thinking about risk focuses on role responsibility. Certain roles, like soldiering, carry with them an obligation to bear risk for the benefit of others."[8]

[8] "Potential Radiation Exposure in Military Operations", Institute of Medicine, National Academy Press, 1999, p. 7.

The issue raised by Shrader-Frechette is what naturally follows from this approach: who can speak for future generations and give informed consent? She argues somewhat persuasively that one group who should not be taken as representing those future generations is the advocate of the action.

Can these be reconciled?

Another National Research Council report recommends dropping the term "stakeholders" and replacing it with "interested and affected parties".[9] Both views of intergenerational equity deal with "affected parties" – far in the future.

Those arguing for emplacement now do so in the belief that leaving the waste on the surface is less safe, in the long run (and we are talking about a very long run), than disposing of the waste in a geologic repository. Those arguing that this does not meet the informed consent guidelines do so in the doubt that the current plans for geologic disposal are safe enough.

So, these arguments are really about safety. These area issues we can address – if we are open, objective, and careful in our analyses.

(b) Environmental justice

In the last 20 years, siting of LULUs (locally unwanted land uses) have been challenged on the grounds that the sites were chosen because the people living there were poor, did not have political power, and often were minorities. Underlying these issues is the one of fairness: is it fair to site a facility in a community which does not want it?

The social science literature has many articles on how not to go about siting a controversial facility. Even the physics literature has articles stressing the need to get local involvement first. A strong proponent of the Yucca Mountain project recently wrote "I and many others might agree that the action of the US Congress to designate only Yucca Mountain as the HLW site to be characterized was **awful** public policy." (emphasis in the original) There will be many articles written expanding on that conclusion.

Steve Brown (United Kingdom) in Denver last fall said the Sellafield opposition raised two unanswered questions: Why here? Why now?

One problem has been the tendency of the natural science and engineering communities to dismiss the views of the social scientists. In some ways, this reminds me of the views of a natural scientist who found that theologians would not listen to him:

[9] "Understanding Risk: Informing Decisions in a Democratic Society", National Research Council, National Academy Press, 1996.

"Professors of theology should not claim the right to regulate with their decrees such professions that do not fall under their authority because you cannot impose on a scientist an opinion about natural phenomena."[10]

We are not quite where Galileo was, but there do seem to be evidences of C.P. Snow's two cultures in many of the discussions regarding Yucca Mountain.

Other than starting over again, the site selection process can not be made fair at this stage in the United States.

I will note that in a representative government, that government does have the responsibility to take actions for the benefit of all its society. Thus, it is valid for the Congress, on the recommendation of the President, to build a repository at Yucca Mountain – or, as one participant in the process noted, "national authority may successfully trump local opposition." It would be best if this use of power was not needed to be exercised.

What must be done now, in the United States, while insuring the long-term safety of the repository, is to pay closer attention to the concerns of two groups of interested and affected parties:
(1) those in Nevada and
(2) those in locations along the likely transportation routes for HLW to come to YM.

It also might be appropriate for the federal government, perhaps Secretary Richardson, to acknowledge that the process has been flawed.

III Transportation hazards

Wherever nuclear waste has been transported in this country, opposition has arisen. This occurred when the debris from the TMI core was transported from Pennsylvania west. It has occurred on both US coasts when spent research reactor fuel is shipped from a port city to a storage site. It has occurred when a reactor operator wants to shift spent fuel from a storage pool at one reactor to one at another.

In spite of DOE films about the safety of transportation casks, and NRC approval of these casks, the public is wary of the potential for serious radiation accidents in the transportation of HLW. One phrase captures the imagination of the opposition, when it is claimed that these transportation casks are "mobile Chernobyls".

While I do not agree with the critics that the casks will pose this hazard, I also do not believe the DOE has put much effort into addressing the public concerns about transportation. Substantial work must be done to work with state and local governments to develop approved routes, training, and equipment purchase. We do have the

[10] Quoted by Tom Siegfried, Dallas Morning News science editor in article "U.S. Society harbors faction devoted to ignoring science". www.dallasnews.com

experience of WIPP, where transportation negotiation was critical in gaining approval to open that site.

IV Plutonium Mines

A leading non-proliferation expert, John Holdren, at a conference in Denver last year, discussed the non-proliferation aspects of geologic repositories. He said:

"From a non-proliferation standpoint, moving in an orderly and timely way toward certifying, opening, filling, and closing geologic repositories brings important benefits, related largely to incentives for shrinking the inventories of directly weapon-usable materials and to [build] confidence in the intended irreversibility of these reductions, but also related ultimately to the additional physical barriers that closed repositories provide. This is an "all deliberate speed" issue, not a "complete immediately" issue. We should not be in such a hurry that we make mistakes in repository selection and design."[11]

Non-proliferation criteria are becoming more prominent in discussions regarding the future of nuclear power. They have not been particularly noticeable in repository debates, with the notable exception of articles by UC Berkeley nuclear engineering professor Per Peterson. Peterson has addressed the question of whether a repository could become a plutonium mine. His answer is yes, if one waits long enough. He concludes that, at some point in the future, if plutonium were desired, it would be cheaper to tunnel into the repository than to build a dedicated reactor to produce plutonium.

However, Peterson's views are more measured than the above might indicate:

"There is likely substantial value in minimizing the total number of repositories that contain spent fuel. This provides additional merit to current efforts toward international or regional collaboration in interim storage and ultimate disposal.

There is also likely no feasible, economical, or particularly desirable route to eliminate the need to dispose of some material of attractiveness comparable to spent fuel…

If old spent fuel repositories existed today, we would consider successful clandestine construction of a tunnel into such a repository to be a major strategic issue, due to the resulting capability to rapidly acquire large quantities of fissile material without international detection. The nature of the long-term threat that must be managed in the future is qualitatively and quantitatively different from the threats we think about and are familiar with today.

The detection of clandestine tunneling into soft geologic media will likely prove to be quite challenging and potentially impossible to do with adequate confidence. The proper design of safeguards systems for hard geologic media also presents challenges, many of

[11] Transparencies from an invited presentation on "Non-Proliferation Aspects of Geologic Repositories", John P. Holdren, International Conference on Geologic Repositories, Denver Colorado, 1 November 2000.

which are site specific and related to the local soil overburden, topology, vegetation, water resources and long-term land-use practices. So far, the work done to study these safeguards issues is inadequate….

My principal arguments are simply that the potential burden of long-term safeguards further motivates current efforts toward regional cooperation for waste disposal; that it could provide motivation for eventually closing the fuel cycle when enough spent fuel accumulates for 3 or 4 large repositories (if nuclear fission continues to play a significant energy role in this time frame); and that safeguards should play a greater role in site selection due to the importance of the hardness of the geologic media in increasing the signatures created by excavation attempts."[12]

Repositories offer greater protection against a terrorist attempt to steal weapons usable material, called in CISAC studies a sub-national threat, as well as making host-nation recovery more likely to be detected. Both are positive for non-proliferation concerns.

Proliferation concerns with HLW include the newer issues surrounding disposal of plutonium made excess by nuclear arms reductions. While not rising to the level of concern for poorly protected storage sites, the large and growing amount of plutonium in spent fuel was identified by the National Academies" CISAC study as a serious issue. Once underground, the concern shifts to adequacy of long-term safeguards, i.e., institutional controls. The National Research Council study on YM concluded that such controls cannot be relied upon for very long periods of time, noting

"This conclusion is founded on the absence of any scientific basis for making projections over the long term of the social, institutional, or technological status of future societies."[13]

It is true that there will be substantial amounts of plutonium in the geologic repositories. In the short term, a few hundred years, institutional controls can be maintained. Beyond that is not possible, for me, to estimate.

V Need for the material in spent fuel

This is a variant of the plutonium mine issue – perhaps the uranium or some of the longer-lived actinides might be needed. This is not really an issue, other than for those who want to reprocess (or process, the newer term). The argument over reprocessing has several factors, including non-proliferation, economics, and symbolism. If spent fuel is directly disposed of, and a country decides to retrieve the material, repositories are being designed for several hundred-year retrievability. After that, mining would be necessary.

[12] Personal communication from P. Peterson, 8 March 2000.
[13] "Technical Bases for Yucca Mountain Standards", National Research Council, National Academy Press, 1995, p. 11.

VI Geologic uncertainty

I see three types:

(1) Short term about which something can be done. An example is the finding of a much faster flow path through the fractured rock at YM. This can be designed around.
(2) Short term about which little can be done. I know of none, but an example would be finding a previously unknown fault quite close to, perhaps under, the repository, with an estimated occurrence time within the next thousand years.
(3) Long term, on the order of hundreds of thousands of years. Recent US government approaches have minimized the importance of this time period.

Rodney Ewing recently questioned the use of a probabilistic performance assessment (PPA) for Yucca Mountain as the sole determinant for acceptance. He believes this approach "moves away form the fundamental precepts of geological disposal" He concluded that "[t}he sole reliance on PPA to provide a quantitative criterion , in conjunction with the elimination of performance standards for individual barriers, the geologically short compliance period, and the extended distance of the point of compliance all combine to reduce substantially the role of the geologic properties of the repository on the waste containment strategy…..The conclusion that there are no insurmountable obstacles in the present analysis and strategy begs the question of whether Yucca Mountain provides effective geologic barriers to radionuclide release…"[14]

DOE must work to make clear what can and cannot be concluded from a performance assessment. Also, the geologic science community must be more involved with DOE reviews.

VII Conclusions

Ten years ago, I addressed whether a resolution could be found to the impasse in moving ahead in HLW disposal. I saw four possible solutions:[15]

(1) The David Farragut Solution, named after the Union naval officer who is quoted as having said at the battle of Mobile Bay, "Damn the torpedoes, full speed ahead." Some in Nevada see this as the congressional approach.
(2) The Technological Solution, in which advocates believe there must be a significantly improved technological fix. In the past, proposals have included
- Sending the waste into the sun, which has both cost and safety concerns (evidenced by the opposition to the Cassini launch),

[14] "Less Geology in the Geological Disposal of Nuclear Waste", Rodney C. Ewing, *Science*, Vol. 286, 15 October 1999, p. 417.
[15] "Nuclear Waste Disposal: Can There be a Resolution?", Proceedings of the First MIT International Conference on the Next Generation of Nuclear Power Technology, 4-5 October 1990, MIT-ANP-CP-001, pp. 7-2 – 7-11.

- Deep seabed disposal, which, while well satisfying scientific criteria, runs afoul of international treaties,
- Deep borehole disposal, which has siting problems as well as potential regulatory issues. It has been used successfully in Russia.
- Accelerator transmutation of waste. This approach has been discussed for at least ten years, and has in the past few years become a major program in several countries, including the United States. Although this technique would not eliminate all radioactive waste, what remains may require isolation for less than one thousand years. In addition to many technical issues, for which the DOE has proposed a six-year, $280 million program, siting still is an issue. At least in the United States, reducing the time of concern to around 1000 years may not resolve the siting controversies, as can be seen by the inability in the US to site any new low level waste sites.

(3) The magic land solution, finding a location where no one lives now or will ever live and where there is absolutely no risk involved in bringing the waste to that location. I grant that some critics – opponents – in the United States at times may seem to be asking for this impossible solution. Some of these critics have dismissed any DOE or other reviews that conclude the Yucca Mountain project should go ahead. Of course, DOE and its predecessor agencies have a poor record on some issues.

These disputes may, but I think will not, reach the level in the U.K. In November 1997, the Parliamentary Office of Science and Technology, in reviewing the rejection of the Sellafield URL application, wrote

"While the current system remains so adversarial however, the scope for almost indefinite argument over the many uncertainties incapable of objective resolution **almost guarantees failure to reach a conclusion in the long run.**" (emphasis in the original)[16]

(4) Wait, the selected solution in many countries and what has been the resulting policy in the US.

The DOE Environmental Impact Statement for Yucca Mountain examined the Leave-in-place option. One scenario assumed loss of institutional control after 100years. Rainwater begins to enter below ground storage vaults in about 2160 and into above ground concrete storage modules in about 2210. The commercial spent fuel storage canisters start to fail after 1000 years. Over the first 100 years, the maximum individual dose is 0.2 mr/yr.[17]

[16] "Radioactive Waste – Where Next?", Parliamentary Office of Science and Technology, P.O.S.T. Report Summary 106, November 1997.

[17] "Impacts from In-Place Storage of Spent Nuclear Fuel", Dee H. Walker, presentation at National Research Council International Workshop on the Disposition of High-Level Radioactive Waste Through Geological Isolation, Irvine, California, 4 November 1999.

Smith, in a 1998 report for the U.K. National Protection Board, examined disposal versus storage for high level waste. He concluded:

"It is considered extremely unlikely that indefinite surface storage could be shown to be acceptable…. It is possible however that adequate safety could be demonstrated over periods greater than a few hundred years…. The problem remains however that, even if safe storage can be demonstrated for times beyond a few hundred years, at some stage the waste would need to be disposed of or stored in a deeper facility."[18]

The "Why now?" question remains difficult to answer.

Solving some of these problems may need new solutions. This will not be easy – it requires what US President Truman in 1948 said:

"Pure research is arduous, demanding, and difficult. It requires unusual intellectual powers. It requires intense concentration, possible only when all the faculties of the scientist are brought to bear on a problem, with no disturbances or distractions." [19]

[18] "Comparison of Final Management Options for High Level Waste: Disposal versus Storage – Identification of Issues", K.R. Smith, NPRB-M956, December 1998, p. 8.
[19] AAAS Annual Meeting, 13 September 1948, *Science*, vol. 108, 24 September 1948, pp. 313-314.